CLAIMS

WHAT IS CLAIMED IS:

1. A method of forming copolymer structures, comprising:

(a) providing a substrate with an imaging layer thereon that will respond to exposure to selected wavelengths to change the wettability of the exposed material of the imaging layer to the components of a selected block copolymer;

(b) exposing the imaging layer to two or more beams of radiation within the selected wavelengths to form interference patterns at the imaging layer to change the wettability of the imaging layer in accordance with the interference patterns in the exposed imaging layer;

(c) depositing a layer of the selected copolymer onto the exposed imaging layer; and

(d) annealing the copolymer layer on the substrate to separate the components of the copolymer in accordance with the pattern of wettability for the components of the copolymer in the underlying imaging layer to replicate the pattern of the imaging layer in the copolymer layer.

2. The method of Claim 1 wherein the beams are at wavelengths in the extreme ultraviolet or shorter and one of the beams is provided directly incident from a source onto the imaging layer and another beam is provided by reflecting a portion of a beam from the same source with a Lloyd's mirror onto the imaging layer at an angle to the beam that is directly incident on the imaging layer.

3. The method of Claim 2 wherein a third beam is provided to the imaging layer by reflecting a portion of a beam from the same source with another Lloyd's mirror onto the imaging layer at an angle to the beam that is directly incident on the imaging layer, the two Lloyd's mirrors positioned at an angle to each other to provide interference patterns at the imaging layer that are at an angle to each other.

4. The method of Claim 3 wherein the angle between the interference patterns of radiation incident on the imaging layer from the three beams is 120° to provide an array of separated regions that are preferentially wet by one of the components of the block copolymer.

5. The method of Claim 2 wherein the source of the beams of radiation is a synchroton.

6. The method of Claim 1 wherein the imaging layer is an alkylsiloxane self-assembled monolayer.

7. The method of Claim 1 wherein the imaging layer is an octadecyltrichlorosilane self-assembled monolayer.

8. The method of Claim 1 wherein the selected copolymer is a copolymer of polystyrene and poly(methyl methacrylate).

9. The method of Claim 1 wherein the interference pattern in the imaging layer has a period of 100 nm or less.

10. The method of Claim 1 wherein the interference pattern in the imaging layer has a period that substantially equals the bulk lamellar period L_0 of the selected copolymer.

11. The method of Claim 1 wherein the thickness of the copolymer layer is equal to or less than the bulk lamellar period L_0 of the selected copolymer.

12. The method of Claim 1 wherein the interference pattern in the imaging layer has a period that is greater than the bulk lamellar period L_0 of the selected copolymer.

13. A method of forming copolymer structures, comprising:

(a) providing a substrate with an imaging layer thereon that will respond to exposure to selected wavelengths to change the wettability of the exposed material of the imaging layer to the components of a selected block copolymer;

(b) exposing the imaging layer to three beams of radiation within the selected wavelengths to form interference patterns at the imaging layer that define an array of separated regions to change the wettability of the imaging layer in accordance with the interference patterns in the exposed imaging layer;

(c) depositing a layer of the selected copolymer onto the exposed imaging layer; and

(d) annealing the copolymer layer on the substrate to separate the components of the copolymer in accordance with the pattern of wettability for the components of the copolymer in the underlying

imaging layer to replicate the pattern of the imaging layer in the copolymer layer.

14. The method of Claim 13 wherein the beams are at wavelengths in the extreme ultraviolet or shorter and one of the beams is provided directly incident from a source onto the imaging layer and two other beams are provided by reflecting portions of a beam from the same source with Lloyd's mirrors onto the imaging layer at angles to the beam that are directly incident on the imaging layer and at angles to the beam that is directly incident on the imaging layer, the two Lloyd's mirrors positioned at an angle to each other to provide interference patterns at the imaging layer that are at an angle to each other.

15. The method of Claim 14 wherein the angle between the interference patterns of radiation incident on the imaging layer from the three beams is 120° to provide an array of separated regions that are preferentially wet by one of the components of the block copolymer.

16. The method of Claim 14 wherein the source of the beams of radiation is a synchrotron.

17. The method of Claim 13 wherein the imaging layer is an alkylsiloxane self-assembled monolayer.

18. The method of Claim 13 wherein the imaging layer is an octadecyltrichlorosilane self-assembled monolayer.

19. The method of Claim 13 wherein the selected copolymer is a copolymer of polystyrene and poly(methyl methacrylate).

20. The method of Claim 19 wherein the interference pattern in the imaging layer has a period of 100 nm or less.

21. The method of Claim 13 wherein the interference pattern in the imaging layer has a period that substantially equals the bulk lamellar period L_0 of the selected copolymer.

22. The method of Claim 13 wherein the thickness of the copolymer layer is equal to or less than the bulk lamellar period L_0 of the selected copolymer.

23. The method of Claim 1 wherein the interference pattern in the imaging layer has a period that is greater than the bulk lamellar period L_0 of the selected copolymer.

24. The method of Claim 13 further including removing the component of the copolymer in the annealed copolymer layer that is in the separated regions of the array.

25. The method of Claim 24 further including depositing a material in openings left in the copolymer layer.

26. A method of forming copolymer structures, comprising:

(a) providing a substrate with an imaging layer thereon that will respond to exposure to selected wavelengths to change the wettability of the exposed material of the imaging layer to the components of a selected block copolymer;

(b) exposing the imaging layer to two or more beams of radiation within the selected wavelengths to form interference patterns at the imaging layer to change the wettability of the imaging layer in accordance with the interference patterns in the exposed imaging layer and such that the interference pattern has a period that is within 20% of the bulk lamellar period L_0 of the selected copolymer;

(c) depositing a layer of the selected copolymer onto the exposed imaging layer; and

(d) annealing the copolymer layer on the substrate to separate the components of the copolymer in accordance with the pattern of wettability for the components of the copolymer in the underlying imaging layer to replicate the pattern of the imaging layer in the copolymer layer.

27. The method of Claim 26 wherein the beams are at wavelengths in the extreme ultraviolet or shorter and one of the beams is provided directly incident from a source onto the imaging layer and another beam is provided by reflecting a portion of a beam from the same source with a Lloyd's mirror onto the imaging layer at an angle to the beam that is directly incident on the imaging layer.

28. The method of Claim 27 wherein a third beam is provided to the imaging layer by reflecting a portion of a beam from the same source with another Lloyd's mirror onto the imaging layer at an angle to the beam that is directly incident on the imaging layer, the two Lloyd's mirrors positioned at an angle to each other to provide interference patterns at the imaging layer that are at an angle to each other.

29. The method of Claim 28 wherein the angle between the interference patterns of radiation incident on the imaging layer from the three beams is 120° to provide an array of separated regions that are preferentially wet by one of the components of the block copolymer.

30. The method of Claim 27 wherein the source of beams of radiation is a synchroton.

31. The method of Claim 26 wherein the imaging layer is an alkylsiloxane self-assembled monolayer.

32. The method of Claim 26 wherein the imaging layer is an octadecyltrichlorosilane self-assembled monolayer.

33. The method of Claim 26 wherein the selected copolymer is a copolymer of polystyrene and poly(methyl methacrylate).

34. The method of Claim 26 wherein the interference pattern in the imaging layer has a period of 100 nm or less.

35. The method of Claim 26 wherein the thickness of the copolymer layer is equal to or less than the bulk lamellar period L_0 of the selected copolymer.

36. A nanostructure comprising:

(a) a substrate having a surface;

(b) a patterned imaging layer of self-assembled monolayer on the surface of the substrate having a pattern therein of separated regions with a spacing of the regions of 100 nm or less;

(c) a block copolymer layer on the imaging layer, the block copolymer layer having separated regions of one component of the copolymer that coincide with the separated regions on the imaging layer.

37. The microstructure of Claim 36 wherein the thickness of the copolymer layer is 100 nm or less.

38. The microstructure of Claim 36 wherein the substrate is formed of single crystal silicon.

39. The microstructure of Claim 36 wherein the imaging layer is an alkylsiloxane self-assembled monolayer.

40. The microstructure of Claim 36 wherein the imaging layer is an octadecyltrichlorosilane self-assembled monolayer.

41. The microstructure of Claim 36 wherein the copolymer layer is a copolymer of polystyrene and poly(methyl methacrylate).